Claims

1. An interconnect structure comprising:
a plurality of interconnected nodes including distinct nodes A, B, C, and D;
data interconnect lines AB_1 and AB_2 coupled from the node A to the node B for sending data from the node A to the node B;
data interconnect lines CD_1 and CD_2 coupled from the node C to the node D for sending data from the node C to the node D;
a data interconnect line AD coupled from the node A to the node D for sending data from the node A to the node D;
means for detecting a condition at the node C;
means for sending a control signal CS from the node C to the node A, the control signal being determined at least in part by the condition at the node C; and
means for sending a message M arriving at the node A to the node B or the node D on a data interconnect line selected from among the data interconnect lines AB_1, AB_2, and AD depending at least partly on the control signal CS.

2. An interconnect structure according to Claim 1 wherein:
the control signal CS is carried from the node C to the node A on a control interconnect line from the node C to the node A.

3. An interconnect structure according to Claim 2 wherein:
every output port reachable from the node A is reachable from the node C;
further comprising:
an output port that is reachable from node A and is not reachable from the node D.

4. An interconnect structure according to Claim 1 wherein:
the line AD passes directly from the node A to the node D.

5. An interconnect structure according to Claim 1 wherein:
the line AD passes through a node between the node A and the node D on the line AD.

6. An interconnect structure according to Claim 1 wherein:
when the condition at the node C is that no messages are moving from the node C to the node D and implicit in a message M at the node A is a condition that a path exists from the node D to a target destination of the message M and the message M has a level of quality of service not less than the threshold of quality of service for the node A to send a message to the node D, then the node A routs a message from the node A to the node D.

7. An interconnect structure according to Claim 1 wherein:
when the condition at the node C is that a low quality of service (LQOS) message is sent from the node C to the node D and no other message is sent from the node C to the node D then the node A can send a high quality of service (HQOS) message to the node D so long as a HQOS message M is present at the node A and a path exists through the node A to an acceptable output port for the message M.

8. An interconnect structure according to Claim 1 wherein:
when the condition at the node C is that a HQOS message is sent from the node C to the node D and no other message is sent from the node C to the node D, then the node A can send either a HQOS or LQOS message from the node A to the node D so long as a message M is present at the node A such that the quality of service of the message M exceeds the minimum quality of service level for sending messages from the node A to the node D and a path exists from the node D to an acceptable output port for the message M.

9. An interconnect structure according to Claim 1 wherein:
when the condition at the node C is that the node C sends a message on each line from the node C to the node D, then the node A can send no messages to the node D.

10. An interconnect structure according to Claim 1 wherein:
when the condition at the node C is that a HQOS message and a LQOS message are sent from the node C to the node D, then the node C sends the HQOS message on the data interconnect line CD_1 and the LQOS message on the data interconnect line CD_2.

11. An interconnect structure according to Claim 1 wherein:
when a message M is sent from the node A to the node D, then the message M is selected from the message set R containing each message at the node A that can reach the target of the message M through the node D.

12. An interconnect structure according to Claim 11 wherein:
no message in the message set R has a higher level of QOS than the message M.

13. An interconnect structure according to Claim 12 wherein:
a message in the message set R with the same level of QOS as the message M is not sent to the node D based on information from the node A.

14. An interconnect structure according to Claim 12 wherein:
the message selecting means selects a message at the node A from the message set R for sending to the node D based on the level of QOS and the node last visited prior to arrival at the node A of the messages in the message set R.

15. A communication interconnect structure comprising:
a plurality of nodes including distinct nodes A, C, and D;

a plurality of interconnect lines coupling the nodes, the node D having one or more message input interconnect lines coupled to the node A and one or more message interconnect lines coupled to the node C; and

a logic that enforces priority relationship rules, the priority relationship rules including:

rules governing the sending of messages from the nodes A and C to the node D so that for a message MA arriving at node A and a message MC arriving at node C, the message MC is not blocked from traveling to node D by the message MA; and

rules governing the sending of messages from the node A to the node D depending at least in part on quality of service levels of messages at node A.

16. A communication interconnect structure according to claim 15 wherein:

the rules governing the sending of messages from the node A to the node D depend at least in part on the number of messages that the node C sends to the node D.

17. A communication interconnect structure according to claim 15 wherein:

the rules governing the sending of messages from the node A to the node D depend at least in part on routing by the node D of message arriving at a node subsequent to the node D.

18. A communication interconnect structure according to claim 17 wherein:

one or more messages N exist so that when the node C sends a message N to the node D, then the node A is not allowed to send messages to the node D.

19. A communication interconnect structure according to claim 15 wherein:

the rules governing the sending of messages from the node A to the node D depend at least in part on the quality of service levels of each of the messages that are sent from the node C to the node D.

20. A communication interconnect structure according to Claim 15 wherein:
the logic that determines the priority relationship associates a threshold value $T_0(A,D)$ with the pair of nodes A and D; and
the rules specify that when the node C sends no messages to the node D then the node A sends a message from the node A to the node D so long as a message M at the node A has a quality of service level greater than $T_0(A,D)$ and a path exists from the node D to a target of the message M.

21. A communication interconnect structure according to Claim 15 wherein:
the rules specify that when the node C sends no messages to the node D then the node A sends a message from the node A to the node D so long as a message M at is present at the node A and a path exists from the node D to a target of the message M.

22. A communication interconnect structure according to Claim 15 wherein:
the rules specify that when the node C sends one LQOS message to the node D and no other message to the node D, the node A sends one HQOS message to the node D so long as a HQOS message M is present at the node A and a path exists through the node D to a acceptable output port of the message M.

23. A communication interconnect structure according to Claim 15 wherein:
the rules specify that when the node C sends one HQOS message to the node D and no other message to the node D, the node A sends a message to the node D so long as a message M exists at the node A and a path exists through the node D to an acceptable output port of the message M.

24. A communication interconnect structure according to Claim 15 wherein:
the logic that determines the priority relationship associates a threshold value $T_0(A,D)$ with the pair of nodes A and D; and

the rules specify that when the node C sends one HQOS message to the node D, the node A sends a message to the node D so long as a message M exists at the node A such that a path exists through the node D to an acceptable output port of the message M and the quality of service level of the message M is not less than $T_0(A,D)$.

25. A communication interconnect structure according to Claim 15 wherein: the rules specify that when the node C sends one LQOS message to the node D and no other messages to the node D, a HQOS message is sent from the node A to the node D so long as a HQOS message M is available at the node A and the message M can reach an acceptable port of the message M through the node D.

26. A communication interconnect structure according to Claim 15 wherein: the rules specify that when the node C sends two messages to the node D, then no message is sent from the node A to the node D.

27. A communication interconnect structure according to Claim 15 wherein: the rules specify that when the node A sends two messages to the node D, then a message may be sent from the node A to the node D so long as logic that enforces priority relationship rules including logic governing the flow of data through the node A is informed that one or more of the messages traveling from the node A to the node D will be routed through the node D to a node X having the property that an output port that is reachable from the node D is not reachable from the node X.

28. A communication interconnect structure according to Claim 15 wherein the interconnect structure is an hierarchical interconnect structure with messages passing from a previous level to a subsequent level, the nodes C and D being on a level subsequent to the level of the node A, the interconnect structure further comprising:

a data interconnect line A_1 coupled to the node A for receiving high quality of service data at the node A from a source on the same level as the node A;

a data interconnect line A_2 coupled to the node A for receiving low quality of service data at the node A from a source on the same level as the node A;

a data interconnect line A_3 coupled to the node A for receiving data at the node A from a source on a previous level to level of the node A; and

a logic associated with the node A that selects messages for transmission to the node D from a message set arriving at the node A for sending from the node A to the node D when the condition at the node C permits a message to be sent to the node D from the node A.

29. A communication interconnect structure according to Claim 28 wherein:

the logic associated with the node A selects a HQOS message arriving at the node A on the data interconnect line A_1 over any other messages in the message set.

30. A communication interconnect structure according to Claim 28 wherein:

the logic associated with the node A selects a HQOS message arriving at the node A on the data interconnect line A_2 in the absence of a HQOS message arriving at the node A on the data interconnect line A_1.

31. A communication interconnect structure according to Claim 28 wherein:

the logic associated with the node A selects a HQOS message arriving at the node A on the data interconnect line A_3 in the absence of a HQOS message arriving at the node A on the data interconnect line A_1 or on the data interconnect line A_2.

32. A communication interconnect structure according to Claim 28 wherein:

the logic associated with the node A selects a LQOS message arriving at the node A on the data interconnect line A_2 in the absence of a HQOS message arriving at the node A.

33. A communication interconnect structure according to Claim 28 wherein:
the logic associated with the node A selects a LQOS message arriving at the node A on the data interconnect line A_3 in the absence of a HQOS message arriving at the node A or a LQOS message arriving at the node A on the data interconnect line A_2.

34. A communication interconnect structure according to Claim 28 further comprising:
a data interconnect line A_4 coupled to the node A for receiving data at the node A from a source on a previous level to level of the node A.

35. A communication interconnect structure according to Claim 34 wherein:
the logic associated with the node A selects a HQOS message arriving at the node A on the data interconnect line A_4 in the absence of a HQOS message arriving at the node A on the data interconnect line A_1, the data interconnect line A_2, or the data interconnect line A_3.

36. A communication interconnect structure according to Claim 34 wherein:
the logic associated with the node A selects a LQOS message arriving at the node A on the data interconnect line A_4 in the absence of a HQOS message arriving at the node A or a LQOS message arriving at the node A on the data interconnect line A_2 or on the data interconnect line A_3.

37. An interconnect apparatus, comprising:
a plurality of nodes; and
a plurality of interconnect lines selectively coupling the nodes in a hierarchical multiple level structure with the level of a node being determined entirely by the position of the node in the structure in which data moves unilaterally from a source level to a destination level or laterally along a level of the multiple level structure, a plurality of data messages including high quality-of-service (HQOS) messages and low

quality-of-service (LQOS) messages being transmitted through the multiple level structure from a source node to a designated destination node, a level of the multiple levels including:

one or more groups of nodes, the data messages being transmitted to a group of the one or more groups of nodes on a path to a target, a group of the one or more groups including:

a plurality of nodes, a single data message being transmitted to a node N of the plurality of nodes of a group unilaterally toward the destination level if the node is not blocked and otherwise one or more data messages being transmitted laterally if the node is blocked, the data messages being transmitted based at least partly on quality of service of the messages.

38. A network communicating messages in a sequence of discrete time steps, the network comprising:

a plurality of nodes, the nodes including communication devices that receive messages and send messages, the messages including high quality-of-service (HQOS) messages and low quality-of-service (LQOS) messages; and

a plurality of interconnect lines L interconnecting communication devices at the plurality of nodes, a node N of the plurality of nodes including:

a connection to one or more interconnect lines L_{UN} capable of transmitting a plurality of messages from a device U to the node N;

a connection to an interconnect line L_{VN} for transmitting a message from a device V to the node N;

the network having a precedence relationship $P_N(U,V)$ relating to the node N and the devices U and V such that the device U has precedence over the device V in sending a message to the node N so that for one or more messages M_U at the device U that are directed to the node N via the interconnect lines L_{UN} at a time step t and a message M_V at the device V that is directed to the node N via the interconnect line L_{VN}

also at a time step t, the one more messages M_U are successfully sent to the node N and the node V uses a control signal to decide where to send the message M_V, the precedence relationship $P_N(U,V)$ being determined at least partly by quality of service of the messages.

39. A network comprising:

a plurality of nodes N; and

a plurality of interconnect lines L connecting the plurality of nodes N in a predetermined pattern, the interconnect lines carrying messages M and control signals C, the messages including high quality-of-service (HQOS) messages and low quality-of-service (LQOS) messages, the messages M and control signals C being received by a node of the plurality of nodes at a discrete time step t and the messages M being moved to subsequent nodes of the plurality of nodes in an immediately subsequent discrete time step t+1, the plurality of interconnect lines L connecting the plurality of nodes N to include:

a node A having a message input interconnection for receiving a message M_A, a control input interconnection for receiving a control signal C_A, a direct message output interconnection to a node D, a plurality of direct message output interconnections to a node E, a direct control output interconnection to a device G, and a control logic for determining whether the message M_A is sent to the node D or the node E based on:

(1) the control signal C_A;

(2) a location of the node A within the plurality of interconnect lines L; and

(3) a routing information contained in the message M_A, the routing information including an indication of quality of service.

40. A network capable of carrying a plurality of messages M concurrently, the messages including high quality-of-service (HQOS) messages and low quality-of-service (LQOS) messages, the network comprising:

a plurality of output ports P;

a plurality of nodes N, the individual nodes N including a plurality of direct message input interconnections and a plurality of direct message output interconnections, the individual nodes N for passing messages M to predetermined output ports of the plurality of output ports P, the predetermined output ports P being designated by the messages M; and

a plurality of interconnect lines in an interconnect structure selectively coupling the nodes in a hierarchical multiple level structure arranged to include a plurality of J+1 levels in an hierarchy of levels arranged from a lowest destination level L_0 to a highest level L_J which is farthest from the lowest destination level L_0, the output ports P being connected to nodes at the lowest destination level L_0, the level of a node being determined entirely by the position of the node in the structure,

the network including a node A of the plurality of nodes N, a control signal operating to limit the number of messages that are allowed to be sent to the node A to eliminate contention for the predetermined output ports of the node A so that the messages M are sent through the direct message output connections of the node A to nodes H that are a level L no higher than the level of the node A, the nodes H being on a path to the designated predetermined output ports P of the messages M, the control signal being determined at least partly according to message quality of service.

41. An interconnect apparatus, comprising:

a plurality of nodes; and

a plurality of interconnect lines in an interconnect structure selectively coupling the nodes in a hierarchical multiple level structure arranged to include:

a plurality of J+1 levels with J an integer greater than 0 in an hierarchy of levels arranged from a lowest destination level L_0 to a highest level L_J with the level of a node being determined entirely by the position of the node in the structure, the interconnect structure transmitting a plurality of multiple-bit

messages entering the interconnect structure unsorted through a plurality of input ports, individual messages M of the plurality of messages being self-routing and including high quality-of-service (HQOS) messages and low quality-of-service (LQOS) messages, the individual messages M moving in a plurality of ways including three ways which are sufficient for the message M to exit the interconnect structure through an output port designated by the message M, movement of the message M being determined by quality of service of the message M, the three ways being:

(1) the message M enters a node in the interconnect structure from a device external to the interconnect structure, the message M designating one or more designated output ports;

(2) the message M moves through a node in the interconnect structure to a designated output port, a time T being associated with the node such that the message M arriving at the node is selectively transmitted within the time T of the message's arrival at the node; and

(3) the message M moves either: (i) through a node U on a level L_k of the interconnect structure to a different node V on the same level L_k in combination with another message, if available, or (ii) moves through the node U on a level L_k of the interconnect structure to a node W on a level L_i nearer in the hierarchy to the destination level L_0 than the level L_k, a time T_U being associated with the node U such that the message M arriving at the node U is selectively transmitted within the time T_U of the message M arrival at the node U.

42. An interconnect structure comprising:

a plurality of nodes; and

a plurality of interconnect lines in an interconnect structure selectively coupling the nodes in a structure, the interconnect structure transmitting a plurality of multiple-bit messages entering the interconnect structure unsorted through a plurality of input ports, an individual message M of the plurality of messages being self-routing, the interconnect structure including:

a node E having a first data input interconnection from a node A and a second data input interconnection from a node F distinct from the node A; and

a control interconnection between the node A and node F for carrying a control signal to resolve contention for sending messages to the node E, the control signal resolving contention at least partly on the basis of quality of service.

43. A method of moving messages through an interconnect structure comprising:

providing:

a plurality of nodes interconnected in a hierarchy including distinct nodes A, B, C, and D, the nodes A and B being on a level in the hierarchy and the nodes C and D being on a next level in the hierarchy;

data interconnect lines B_1 and B_2 coupled from the node A to the node B for sending data from the node A to the node B;

a data interconnect line D_1 coupled from the node C to the node D for sending data from the node C to the node D;

a data interconnect line D_2 coupled from the node C to the node D for sending data from the node C to the node D;

a data interconnect line D_3 coupled from the node A to the node D for sending data from the node A to the node D; and

a control interconnect line S coupled from the node C to the node A for sending a control signal from the node C to the node A;

detecting a condition at the node C;

sending a control signal CS on the line S from the node C to the node A, the control signal being determined by the condition at the node C; and

sending a message M arriving at the node A to the node B or the node D on a data interconnect line selected from among the data interconnect lines B_1, B_2, and D_3 depending at least partly on the control signal CS.

44. A method according to Claim 43 further comprising:

sending the message M from the node A to the node D when the condition at the node C is that no messages are moving from the node C to the node D and a path exists from the node D to the target destination of the message M.

45. A method according to Claim 43 further comprising:

when the condition at the node C is that a low quality of service (LQOS) message M_{LQOS} arrives at the node C with no high quality of service (HQOS) message, sending the message M_{LQOS} from the node C to the node D on the line D_2 for carrying low quality of service messages and sending the control signal CS on the control interconnect line S to indicate the condition,

in response to the control signal CS indicative of the condition, the node A is capable of sending a high quality of service (HQOS) message M_{HQOS} arriving at the node A to the node D on the line B_3 but is not capable of sending a LQOS message to the node D on the line B_3.

46. A method according to Claim 45 further comprising:

in response to the control signal CS indicative of the condition, the node A can send a LQOS message arriving at the node A to the node B on the line B_2.

47. A method according to Claim 43 further comprising:

when the condition at the node C is that a high quality of service (HQOS) message M_{HQOS} arrives at the node C with no low quality of service (LQOS) message, sending the message M_{HQOS} from the node C to the

node D on the line D_1 for carrying high quality of service messages and sends the control signal CS on the control interconnect line S to indicate the condition,

in response to the control signal CS indicative of the condition, the node A is capable of sending either a high quality of service (HQOS) message or a low quality of service (LQOS) message arriving at the node A to the node D on the line B_3.

48. A method according to Claim 43 further comprising:

when the condition at the node C is that a high quality of service (HQOS) message M_{HQOS} and a low quality of service (LQOS) message M_{LQOS} simultaneously arrive at the node C, sending the message M_{HQOS} from the node C to the node D on the line D_1 for carrying high quality of service messages, sends the message M_{LQOS} to the node D on the line C2 for carrying low quality of service messages, and sends the control signal CS on the control interconnect line S to indicate the condition,

in response to the control signal CS indicative of the condition, the node A sends neither a high quality of service (HQOS) message nor a low quality of service (LQOS) message arriving at the node A to the node D on the line B_3.

49. A method according to Claim 48 further comprising:

in response to the control signal CS indicative of the condition, the node A can send a HQOS message and/or a LQOS message arriving at the node A to the node B.

50. A method according to Claim 43 further comprising:

selecting the message M from among a message set R including high quality of service (HQOS) messages and low quality of service (LQOS) messages, the messages having a header including quality of service information and information specifying a target destination for ultimately receiving the message.

51. An interconnect structure for communicating data in packets, the interconnect structure comprising:

a collection of nodes including distinct nodes A, B, C, and D;

a collection of interconnect lines selectively coupling the nodes of the interconnect structure, and

a logic for routing packets through the interconnect structure so that:

the node A is capable of sending packets to the node B or the node D; and

for a packet PA arriving at the node A and a packet PC arriving at the node C, the node C has routing priority over the node A to send messages to the node D in which:

routing of the packet PA at the node A depends upon routing of the packet PC at the node C, and

routing of the packet PC at the node C depends at least partly on a quality of service of the packet PC.

52. An interconnect structure according to Claim 51 wherein:

routing of the packet PC at the node C does not depend on routing of the packet PA at the node A;

the logic routes the packets depending at least in part on N quality of service threshold values $T_i(A,D)$ for routing data from the node A to the node D, the number N being two or more, the threshold values $T_i(A,D)$ being increasing in value from $T_0(A,D)$ to $T_{N-1}(A,D)$;

the collection of interconnect lines including control signal lines for carrying control signal information CS(0) to CS(N-1) corresponding to the threshold values $T_0(A,D)$ to $T_{N-1}(A,D)$;

a plurality of nodes are capable of sending control signals CS(i) to the node A;

on receipt of control information CS(j) at the node A, j being between 0 and N-1, if a packet PA is present at the node A, a path exists through the node D to an acceptable target of the packet PA, and the level of QOS for the node A is at least $T_j(A,D)$, then the node A will send a packet to the node D.

53. An interconnect structure according to Claim 52 wherein:
the logic routes the packets depending at least in part on N quality of service threshold values $T_i(A,D)$ for routing data from the node A to the node D including the threshold values $T_0(A,D)$ and $T_1(A,D)$;
the collection of interconnect lines including control signal lines for carrying control signal information CSI(i) corresponding to the threshold values $T_i(A,D)$ including the control signal information $CSI_0(A,D)$ and $CS_1(A,D)$; and
in the presence of control signal information $CS_N(A,D)$, if a packet PA exists at the node A, a path exists through the node D to an acceptable output port of the packet PA, and the level of QOS for the packet PA is at least $T_N(A,D)$, then the node A sends a packet to the node D.

54. An interconnect structure according to Claim 52 wherein:
the control signal information CS(i) sent by the plurality of control signal sending nodes depends at least partially upon the routing of messages through the node C.

55. An interconnect structure according to Claim 52 wherein:
the control signal information CS(i) sent by the plurality of control signal sending nodes depends at least partially upon the future routing of messages through the node D.

56. An interconnect structure comprising:
a plurality of nodes including the distinct nodes A, B, C, and D;
a collection of lines selectively coupling the nodes of the interconnect structure, including one or more data carrying lines allowing the node A to send messages to the node B, one or more data carrying lines allowing the node A to send data to the node D, and one or more data carrying lines allowing for the node C to send data to the node D; and
a logic for routing packets through the interconnect structure so that:

a message M_C arriving at the node C is not blocked from being routed to the node D by a message M_A arriving at the node A;

messages arriving at the node A are routed by a logic associated with the node A to other nodes in the interconnect structure; and

the logic at node A uses quality of service information from the messages arriving at node A at least in part to route the messages arriving at node A to other nodes in the interconnect structure.